OPTIMIZATION OF PROCESS PARAMETERS IN SHEET METAL FORMING BY USING TAGUCHI METHOD

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SUPERVISOR DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing.

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Name of Panel :
Position :
Date :

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :
Name :
ID Number :
Date :

Dedicated to my beloved father, mother,
sister, and brothers

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ABSTRACT

Sheet metal is one of the most important semi finished products used in the steel industry, and sheet metal forming technology is therefore an important engineering discipline within the area of mechanical engineering. The development of new sheet metal forming processes, tooling and so on has up till now to a large extent been based on experience, rules of thumb and trial-error experiments without or with only little use of scientifically based engineering methods. As mentioned above, experience is not enough, and trial-error experiments are very expensive with regard to both money and time. There is therefore great need for the development of both theoretical and experimental engineering methods. In this case, Taguchi method was selected to design of experiment using the statistica software version 7 which enables the problems to be tackled effectively; the punching process has been chosen to form the sheet metal. The objective of the project is to determine the optimize parameters. The parameters to be considered in this study are punching tonnage, the sheet thickness, the sheet length and the sheet width.

ABSTRAK

Kepingan logam adalah salah satu sebahagian produk siap yang penting yang digunakan dalam industri keluli dan kerana itu teknologi pembentukkan kepingan logam merupakan salah satu disiplin dalam bidang kejuruteraan mekanikal. Pembangunan dalam proses pembentukkan kepingan logam, alatan dan lain-lain sehingga sekarang adalah semakin meluas berdasarkan pengalaman, peraturan ibu jari dan eksperimen cuba jaya tanpa atau dengan hanya sedikit sahaja penggunaan saintifik berdasarkan kaedah kejuruteraan. Sebagaimana diberitahu di atas, pengalaman sahaja tidak mencukupi, dan eksperimen cuba jaya adalah terlalu mahal dan ini membazirkan duit dan masa. Oleh yang demikian, keperluan yang besar untuk pembangunan termasuk kedua - dua kaedah kejuruteraan iaitu teoritikal dan eksperimen. Dalam kes ini, kaedah Taguchi telah dipilih untuk mereka eksperimen dengan menggunakan perisian STATISTICA versi 7 yang mana membolehkan masalah dapat diselesaikan dengan secara berkesan. Proses tumbukan (punching) telah dipilih untuk membentuk kepingan logam. Objektif projek ini ialah untuk mengenal pasti parameter-parameter yang terbaik dalam proses tumbukan (punching). Parameter-parameter yang dipertimbangkan dalam kajian ini adalah daya tumbukan, ketebalan kepingan, panjang kepingan, dan lebar kepingan.

TABLE OF CONTENTS

		PAGE
SUPERVISOR'S DECLARATION		i
STUDENT'S DECLARATION		ii
DEDICATION		iii
ACKNOWLEDGEMENTS		iv
ABSTRACT		v
ABSTRAK		vi
TABLE OF CONTENTS		vii
LIST OF TABLES		x
LIST OF FIGURES		xii

CHAPTER 1 INTRODUCTION

1.1	Background	1
1.2	Problem Statement	2
1.3	Objective	2
1.4	Scope of study	3
1.5	Taguchi Designs	3

CHAPTER 2 LITERATURE REVIEW

2.1	Introduction	4
2.2	Sheet metal forming	6
	2.2.1 sheet metal working terminology	6
	2.2.2 three major categories of sheet metal process	6
	2.2.3 sheet metal characteristics and their formability	8

2.3	Taguchi method	9
	2.3.1 Introduction to Taguchi Method	9
	2.3.2 Description of the Taguchi method	9
	2.3.3 Taguchi Methods for Design of Experiments	10
2.4	Conclusion	12
2.5	STATISTICA (DESIGN OF EXPERIMENTS) VERSION 7	13
	2.5.1 Introduction	13
	2.2.2 Taguchi Robust design	15

CHAPTER 3 METHODOLOGY

3.1	Introduction	17
3.2	Process of Sheet- Metal forming	17
3.3	Equipment for Sheet-Metal forming	18
3.4	Taguchi Methodology	19

CHAPTER 4 RESULTS AND DISCUSSION

4.1	Design and Analysis of Punching Parameters	23
4.2	Orthogonal Array Experiment	23
4.3	Analysis of the S/N Ratio	27
4.4	Analysis of Variance (ANOVA)	33
4.5	Confirmation Test	36

CHAPTER 5 CONCLUSION

5.1	Conclusion	38

REFERENCES	39
APPENDICES	41-44

LIST OF TABLES

Table No.		Page
2.1	Characteristics of Sheet-Metal Forming Processes	7
2.2	Characteristics of Metals Important in Sheet-Forming Operations	8
3.1	Control factors and levels	20
3.2	The L_9 (3^4) OA (parameters assigned) with response.	21
4.1	L9 Orthogonal Array	24
4.2	Control Factor and Their Level	25
4.3	Control Factor and Their Level Value	25
4.4	Factor and Levels with Unit	26
4.5	Typical Turret Press Manufacturing Characteristics	26
4.6	Result for Cycle Time and S/N ratio	28
4.7	S/N ratio Response Table for Cycle Time	29
4.8	Different between Max and Min S/N ratio response for Cycle Time	29
4.9	Average S/N ratio by Factor Level	31
4.10	Result for Cost Operation and S/N ratio	32

4.11	The S/N response table (Max – Min) for Cost Operation	32
4.12	Results of the Analysis of Variance for Cycle Time	35
4.13	Results of the ANOVA for Cycle Time using Effect Pooled into Error term	35
4.14	Results of the Analysis of Variance for Cost Operation	35
4.15	Results of the ANOVA for Costs Operation using Effect Pooled into Error Term	36
4.16	Results of Confirmation Tests For Cycle Time	36
4.17	Results of Confirmation Tests for Cost Operation	37

LIST OF FIGURES

Figure No.		Page
2.1	Outline of sheet-metal forming process	5
2.2	Taguchi robust design experiments.	15
3.1	Example of the Parts of Product Produce by Punching Process	18
3.2	Sheet-metal forming machine	19
3.3	The tool of sheet-metal forming machine	19
4.1	S/N ratios Graph for Cycle Time	30
4.2	S/N ratios Graph for Cost Operation	33

CHAPTER 1

INTRODUCTION

1.1 Background

Sheet metal is one of the most important semi finished products used in the steel industry, and sheet metal forming technology is therefore an important engineering discipline within the area of mechanical engineering.

Sheet metal is an "old" material, and one could be tempted to believe, that all the necessary knowledge and methods within the area of sheet metal forming have been established to such a degree, that no further research in this area is required. This is not so, on the contrary, research in this area is of high demand and this is partly due to during the last decade, there has been a tremendous development of sheet materials and sheet forming technology. A large number of new sheet qualities, for example HSLA-steel and pre-coated steel, have come into the market place. These new sheet materials have other properties, example higher strength and more ductility, than conventional sheet steel, and have therefore to be worked differently. The experience with the forming of conventional sheet steel can only partly be transferred to the forming of the new sheet steel types. There is therefore a great need for research regarding how these new sheet steels behave in different forming processes in order to be able to fully utilize these new improved sheet steels.

The development of new sheet metal forming processes, tooling and so on has up till now to a large extent been based on experience, rules of thumb and trial-error experiments without or with only little use of scientifically based engineering methods. As mentioned above, experience is not enough, and trial-error experiments are very expensive with regard to both money and time. There is therefore great need for the development of both theoretical and experimental engineering methods which enable the problems to be tackled effectively; this is necessary to reduce production cost and to reduce the lead time between design and production.

The demands required from the sheet metal processes are increasing both with regard to the tolerance requirements of the finished part and with regard to the complexity (example near net shape forming). To meet these requirements, a detailed knowledge about the material properties, the friction conditions and the forming process is needed. This knowledge can only be obtained by using advanced theoretical and experimental engineering methods.

1.2 Problem Statements

Sheet metal forming is a major fabrication process in many sectors of industry. Throughout the years, technological advances have allowed the production of extremely complex parts. Sheet metal forming refers to various processes used to convert sheet metal into different shapes for a large variety of finished parts such as aluminum cans and automobile body panels. So, the optimize parameters in machines such as punching process in sheet metal forming must be to determine to get the optimal value. So that the production rate can be increased without increase the cost operation and reduce the cycle time. Then, the manufacturer can get the high demand and more profitable.

1.3 Objective

There are 2 main objectives in this study:

(a) To determine the optimize parameters in punching process.

(b) To analyze the parameters by using Taguchi Method.

1.4 Scope of Study

The scope of study is divided in three sections:

(a) Process parameters,

(b) Sheet metal forming and,

(c) Taguchi method.

1.5 Taguchi Designs

Genichi Taguchi, a Japanese engineer, proposed several approaches to experimental designs that are sometimes called "Taguchi Methods." Taguchi proposed several approaches to experimental designs called Taguchi method This method utilizes an orthogonal array, which is a form of fractional factorial design containing a representative set of all possible combination of experimental conditions. Using Taguchi method, a balanced comparison of levels of the process parameters and significant reduction in the total number of required simulations can both be achieved.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Products made by sheet-metal forming processes are around us. They include metal desks, file cabinets, appliances, car bodies, aircraft fuselages, and beverage cans. Sheet forming dates back to 5000 B.C, when household utensils and jewelry were made by hammering and stamping gold, silver and copper.

Compared to those made by casting and by forging, sheet-metal parts offer the advantages of light weight and versatile shape. Because of its low cost and generally good strength and formability characteristics, low-carbon steel is the most commonly used sheet metal. For aircraft and aerospace application, the common sheet materials are aluminum and titanium.

There are 2 stages of sheet metal processes consist:

- Cutting the large rolled sheets and,
- Further processed into desired shape.

For such huge production volumes of the same part during long product life cycles, well-established forming methods enable a secure, cost-effective manufacturing of complex parts, compensating high investments in required complex tools and equipment as well as long preliminary development times until production [1] But the current market demand for individualization of products has activated research in the development of faster and cost-effective tool manufacturing techniques suitable for low production volumes.

This demand along with strong competition among several producers and the continuous reduction of product's life cycle requires a faster and cost-effective development of high quality products with high flexibility for design changes supporting the innovation imposed to those products [2].

As a result, sample parts, prototypes and low volume series parts have to be available at very short term.

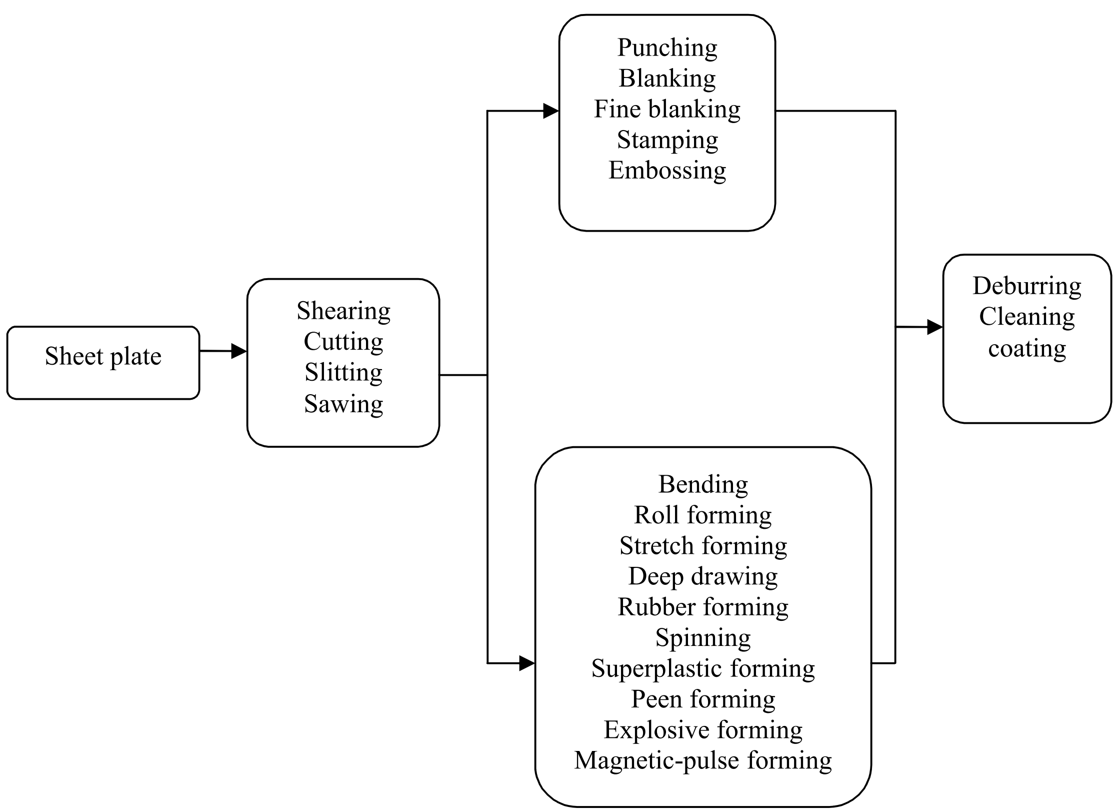

Figure 2.1: Outline of sheet-metal forming process

2.2 Sheet Metal forming

2.2.1 Sheet-metal working terminology

There are 3 main ideas about sheet-metal working terminology:

1. "Punch-and-die"
   - Tooling to perform cutting, bending, and drawing.
2. "Stamping press"
   - Machine tool that performs most sheet metal operations.
3. "Stampings"
   - Sheet metal products.

2.2.2 Three Major Categories of Sheet Metal Processes

The three main categories of sheet metal processes include:

1. Cutting
   - Shearing to separate large sheets; or cut part perimeters or make holes in sheets.
2. Bending
   - Straining sheet around a straight axis.
3. Drawing
   - Forming of sheet into convex or concave shapes.

The table 2.1 show that typically the characteristics of sheet-metal forming processes.

Table 2.1: Characteristics of Sheet-Metal Forming Processes

Process	Characteristics
Roll forming	• long parts with constant complex cross-sections; • good surface finish; • high production rates; • high tooling costs.
Stretch forming	• large parts with shallow contours; • suitable for low-quantity production; • high labor costs; • tooling and equipment costs
Drawing	• shallow or deep parts with relatively simple shapes; • high production rates; • high tooling and equipment costs.
Stamping	• includes a variety of operations, such as punching, embossing, bending, flanging, and coining; • simple or complex shapes formed at high production rates; • tooling and equipment costs can be high, but labor cost is low.
Rubber forming	• drawing and embossing of simple or complex shapes; • sheet surface protected by rubber membranes; • flexibility of operation; • low tooling costs.
Spinning	• small or large axisymmetric parts; • good surface finish; low tooling costs, but labor costs can be high unless operations are automated.

Source: Manufacturing and Engineering Technology

2.2.3 Sheet- metal characteristics and their formability

Some characteristics of sheet metal will effects on the overall manufacturing process and their characteristics are shown on table 2.2. The characteristics of metals are important in sheet-metal forming operations.

Table 2.2: Characteristics of Metals Important in Sheet-Forming Operations

Characteristics	Importance
Elongation	Determines the capability of the sheet metal to stretch without necking and failure.
Yield-point elongation	Typically observed with mild-steel sheets, flame like depressions on the sheet surface, can be eliminated by temper rolling but sheet must be formed within a certain time after rolling.
Anisotropy (planar)	Exhibits different behavior in different planar directions, present in cold-rolled sheets because of preferred orientation or mechanical fibering, causes caring in deep drawing, can be reduced or eliminated by annealing but at lowered strength.
Residual stresses	Typically caused by no uniform deformation during forming, results in part distortion when sectioned, can lead to stress-corrosion cracking, reduced or eliminated by stress relieving.
Springback	Due to elastic recovery of the plastically deformed sheet after unloading, causes distortion of part and loss of dimensional accuracy, can be controlled by techniques such as overbending and bottoming of the punch.
Wrinkling	Causes by compressive stresses in the plane of the sheet, can be objectionable, depending on its extent, can be useful in imparting stiffness to parts by increasing their section modulus, and can be controlled by proper tool and die design.

2.3 Taguchi method

2.3.1 Introduction to Taguchi Method

Genichi Taguchi (born January 1, 1924 in Tokamachi, Japan) is an engineer and statistician. Taguchi methods are statistical methods developed by Genichi Taguchi to improve the quality of manufactured goods and, more recently, to biotechnology, [3] marketing and advertising.

2.3.2 Description of the Taguchi method

Taguchi is the developer of the Taguchi method [4]. He proposed that engineering optimization of a process or product should be carried out in a three-step approach:

- system design,
- parameter design, and
- tolerance design.

In system design, the engineer applies scientific and engineering knowledge to produce a basic functional prototype design, this design including the product design stage and the process design stage. In the product design stage, the selection of materials, components, tentative product parameter values, etc., are involved. As to the process design stage, the analysis of processing sequences, the selections of production equipment, tentative process parameter values, etc., are involved. Since system design is an initial functional design, it may be far from optimum in terms of quality and cost.

Following on from system design is parameter design. The objective of parameter design is to optimize the settings of the process parameter values for improving quality characteristics and to identify the product parameter values under the optimal process parameter values. In addition, it is expected that the optimal process parameter values obtained from parameter design are insensitive to variation in the environmental conditions and other noise factors.

Finally, tolerance design is used to determine and analyze tolerances around the optimal settings recommend by the parameter design. Tolerance design is required if the reduced variation obtained by the parameter design does not meet the required performance, and involves tightening tolerances on the product parameters or process parameters for which variations result in a large negative influence on the required product performance. Typically, tightening tolerances means purchasing better-grade materials, components, or machinery, which increases cost.

However based on the above discussion, parameter design is the key step in the Taguchi method to achieving high quality without increasing cost. Basically, experimental design methods [5]were developed originally by Fisher [6]. However, classical experimental design methods are too complex and not easy to use.

Furthermore, a large number of experiments have to be carried out when the number of the process parameters increases. To solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. The experimental results are then transformed into a signal-to-noise (S/N) ratio.

2.3.3 Taguchi Methods for Design of Experiments

Taguchi methods of experimental design provide a simple, efficient and systematic approach for the optimization of experimental designs for performance quality and cost. It has been proved successful to many manufacturing situations [7, 8, 9, 10, 11 and 12].